IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant(s): **Agnello et al.** Examiner:

Serial No. : Art Unit:

Filing Date: Docket No.: **BU9-98-183-US2**

Title: **WET CLEANS FOR COBALT DISILICIDE PROCESSING**

Commissioner For Patents
Washington, D.C. 20231

PRELIMINARY AMENDMENT

Sir:

Prior to initial examination on the merits, please amend the above-identified application as follows:

IN THE SPECIFICATION

Please insert The following paragraph between lines 1 and 2 on page 1.

This application is a divisional of Serial No. 09/296,338, filed on April 22, 1999.

The paragraphs beginning on page 2, line 8 and ending on page 3, line 21 are replaced by the following paragraphs:

The present invention provides a structure, comprising a layer of cobalt disilicide, wherein the layer of cobalt disilicide is substantially free of cobalt monosilicide, and

wherein there is substantially no stringer of an oxide of titanium on the layer of cobalt disilicide.

The present invention provides a structure, comprising:

a layer of cobalt disilicide, wherein the layer of cobalt disilicide is substantially free of cobalt monosilicide;

a patch of an oxide of titanium, wherein the patch is on the layer of cobalt disilicide; and

a reagent in contact with the patch at a temperature, wherein the reagent is adapted to remain in contact with the patch for a period of time, wherein the reagent removes the patch within the period of time, wherein the reagent does not chemically react with the layer of cobalt disilicide, and wherein the reagent comprises water, ammonium hydroxide, and hydrogen peroxide.

The present invention provides a structure having a substrate, wherein the substrate includes:

an insulated-gate field effect transistor (FET), wherein the FET includes a source, a drain, and a gate;

a first layer of cobalt disilicide on the source, said first layer having substantially no cobalt monosilicide, and said first layer having substantially no stringer of an oxide of titanium thereon;

a second layer of cobalt disilicide on the drain, said second layer having substantially no cobalt monosilicide, and said second layer having substantially no stringer of an oxide of titanium thereon; and

a third layer of cobalt disilicide on the gate, said third layer having substantially no cobalt monosilicide, and said third layer having substantially no stringer of an oxide of titanium thereon.

The present invention provides a structure having a substrate, wherein the substrate includes:

an insulated-gate field effect transistor (FET), wherein the FET includes a source, a drain, and a gate;

a first layer of cobalt disilicide on the source, said first layer having substantially no cobalt monosilicide;

a second layer of cobalt disilicide on the drain, said second layer having substantially no cobalt monosilicide;

a third layer of cobalt disilicide on the gate, said third layer having substantially no cobalt monosilicide;

a patch of an oxide of titanium on a region of cobalt disilicide, said region selected from the group consisting of the first layer of cobalt disilicide, the second layer of cobalt disilicide, the third layer of cobalt disilicide, and combinations thereof;

a reagent in contact with the patch at a temperature, wherein the reagent is adapted to remain in contact with the patch for a period of time, wherein the reagent removes the patch within the period of time, wherein the reagent does not chemically react with the first layer of cobalt disilicide, wherein the reagent does not chemically react with the second layer of cobalt disilicide, wherein the reagent does not chemically react with the third layer of cobalt disilicide, and wherein the reagent comprises water, ammonium hydroxide, and hydrogen peroxide.

Use of a FET in the preceding structures is merely illustrative, and any semiconductor structure may be used instead of a FET in the preceding structures.

The structures of the present invention have the advantage of not including, or facilitating removal of, stringers of one or more oxides of titanium.

IN THE ABSTRACT

The Abstract as amended herein is as follows.

A structure relating to removal of an oxide of titanium generated as a byproduct of a process that forms cobalt disilicide within an insulated-gate field effect transistor (FET). The structure may comprise a layer of cobalt

disilicide that is substantially free of cobalt monosilicide, with substantially no stringer of an oxide of titanium on the layer of cobalt disilicide. The structure may alternatively comprise a layer of cobalt disilicide, a patch of an oxide of titanium, and a reagent in contact with the patch at a temperature and for a period of time. The layer is substantially free of cobalt monosilicide. The patch is on the layer of cobalt disilicide. The reagent is adapted to remove the patch within the period of time. The reagent does not chemically react with the layer of cobalt disilicide, and the reagent comprises water, ammonium hydroxide, and hydrogen peroxide.

IN THE CLAIMS

Please cancel claims 1-24. Please add new claims 25-38 as follows:

25. (NEW) A structure, comprising a layer of cobalt disilicide, wherein the layer of cobalt disilicide is substantially free of cobalt monosilicide, and wherein there is substantially no stringer of an oxide of titanium on the layer of cobalt disilicide.

26. (NEW) The structure of claim 25, further comprising a layer of silicon, wherein the layer of cobalt disilicide is on the layer of silicon.

27. (NEW) The structure of claim 26, wherein the layer of cobalt disilicide is in contact with a reagent comprising water, ammonium hydroxide, and hydrogen peroxide.

28. (NEW) A structure, comprising:

a layer of cobalt disilicide, wherein the layer of cobalt disilicide is substantially free of cobalt monosilicide;

a patch of an oxide of titanium, wherein the patch is on the layer of cobalt disilicide; and

a reagent in contact with the patch at a temperature, wherein the reagent is adapted to remain in contact with the patch for a period of time, wherein the reagent removes the patch within the period of time, wherein the reagent does not chemically react with the layer of cobalt disilicide, and wherein the reagent comprises water, ammonium hydroxide, and hydrogen peroxide.

29. (NEW) The structure of claim 28, wherein:

the ammonium hydroxide comprises approximately 4 percent of a total reagent volume of the reagent,

the hydrogen peroxide comprises approximately 4 percent of the total reagent volume,

the temperature is approximately between 45 degrees celsius and 95 degrees celsius, and

the period of time is approximately between 30 seconds and 10 minutes.

30. (NEW) The structure of claim 28, further comprising a layer of silicon, wherein the layer of cobalt disilicide is on the layer of silicon.

31. (NEW) The structure of claim 30, wherein a minimum period of time for removing the patch is inversely dependent on the temperature.

32. (NEW) A structure having a substrate, wherein the substrate includes:

an insulated-gate field effect transistor (FET), wherein the FET includes a source, a drain, and a gate;

a first layer of cobalt disilicide on the source, said first layer having substantially no cobalt monosilicide, and

said first layer having substantially no stringer of an oxide of titanium thereon;

a second layer of cobalt disilicide on the drain, said second layer having substantially no cobalt monosilicide, and said second layer having substantially no stringer of an oxide of titanium thereon; and

a third layer of cobalt disilicide on the gate, said third layer having substantially no cobalt monosilicide, and said third layer having substantially no stringer of an oxide of titanium thereon.

33. (NEW) The structure of claim 32, further comprising:

a first insulating structure bordering a side of the source and bordering a side of the first layer of cobalt disilicide; and

a second insulating structure bordering a side of the drain and bordering a side of the second layer of cobalt disilicide.

34. (NEW) The structure of claim 32, wherein the first layer of cobalt disilicide, the second layer of cobalt disilicide, and the third layer of cobalt disilicide are each in contact with a reagent comprising water, ammonium hydroxide, and

hydrogen peroxide.

35. (NEW) A structure having a substrate, wherein the substrate includes:

an insulated-gate field effect transistor (FET), wherein the FET includes a source, a drain, and a gate;

a first layer of cobalt disilicide on the source, said first layer having substantially no cobalt monosilicide;

a second layer of cobalt disilicide on the drain, said second layer having substantially no cobalt monosilicide;

a third layer of cobalt disilicide on the gate, said third layer having substantially no cobalt monosilicide;

a patch of an oxide of titanium on a region of cobalt disilicide, said region selected from the group consisting of the first layer of cobalt disilicide, the second layer of cobalt disilicide, the third layer of cobalt disilicide, and combinations thereof;

a reagent in contact with the patch at a temperature, wherein the reagent is adapted to remain in contact with the patch for a period of time, wherein the reagent removes the patch within the period of time, wherein the reagent does not chemically react with the first layer of cobalt disilicide, wherein the reagent does not chemically react

with the second layer of cobalt disilicide, wherein the reagent does not chemically react with the third layer of cobalt disilicide, and wherein the reagent comprises water, ammonium hydroxide, and hydrogen peroxide.

36. (NEW) The structure of claim 35, wherein:

the ammonium hydroxide comprises approximately 4 percent of a total reagent volume of the reagent,

the hydrogen peroxide comprises approximately 4 percent of the total reagent volume,

the temperature is approximately between 45 degrees celsius and 95 degrees celsius, and

the period of time is approximately between 30 seconds and 10 minutes.

37. (NEW) The structure of claim 35, further comprising:

a first insulating structure bordering a side the source and bordering a side of the first layer of cobalt disilicide; and

a second insulating structure bordering a side of the drain and bordering a side of the second layer of cobalt disilicide.

38. (NEW) The structure of claim 35, wherein a minimum period of time for removing the patch is inversely dependent on the temperature.

REMARKS

If the Examiner believes that anything further is necessary in order to place the application in better condition for allowance, the Examiner is requested to contact Applicants' undersigned representative at the telephone number listed below.

Respectfully submitted,

Jack P. Friedman

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Dated: 8/27/2001

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Appendix A: Identification of Amended Material

The paragraphs beginning on page 2, line 8 and ending on page 3, line 21 are amended as follows:

[The present invention provides a method of removing an oxide of titanium which is generated as a byproduct of a process that forms cobalt disilicide within a semiconductor device such as an FET.

The present invention provides an FET within a substrate, wherein the FET is a gate-insulated field effect transistor comprising a source, a drain, a gate, a gate insulator, and a channel. Typically, the substrate is first precleaned with a suitable reagent such as hydrofluoric acid (HF). This precleaning removes a film of silicon dioxide (SiO_2) that became deposited on a surface of the layer of silicon as a consequence of prior processing or of prior exposure of the substrate to air at room temperature. Next, a layer of cobalt is formed on a top surface of the substrate by use of a sputtering process such as with argon gas in a low-pressure chamber. The top surface of the substrate comprises a portion of the top surface of each of the source, drain, gate, and insulating structures. Next, a layer of titanium nitride is formed on the layer of cobalt by use of a second sputtering process such as with argon gas

and nitrogen gas in a low-pressure chamber. Then a first annealing of the substrate causes portions of the layer of cobalt to react with the source, drain, and gate to transform a top portion of each of the source, drain, and gate into a silicide zone comprising a greater amount of cobalt silicide (CoSi) and a lesser amount of cobalt disilicide ($CoSi_2$). Unreacted cobalt remains after the preceding annealing step, particularly on top of the isolating structures. The layer of titanium nitride and the unreacted cobalt are removed by a first cleaning with a reagent such as one comprising hydrogen peroxide and sulfuric acid. Impurities comprising titanium, cobalt, silicon, oxygen, and/or nitrogen may be present on the substrate after the first cleaning and a second cleaning is performed to remove the impurities. The first and second cleanings in combination may not successfully remove all impurities and impurities comprising titanium may be present on the substrate. Next, a second annealing process transforms cobalt monosilicide to cobalt disilicide in the silicide zone, thereby forming the desired cobalt disilicide within the FET. Nonetheless, a stringer of an oxide of titanium may be present on one or more of the cobalt disilicide areas of the silicide zone following the second

annealing, and all such stringers should be removed to prevent shorting of adjacent electrical structures of, within, or coupled to, the FET. The final step removes the stringers by applying a reagent to the substrate at a suitable temperature, and for a period of time, wherein the reagent does not chemically react with the cobalt disilicide.

Use of an FET in the preceding method is illustrative. The preceding process steps may be applied to any semiconductor structure to form cobalt disilicide volumes that are free of stringers of an oxide of titanium.

Thus, the invention has the advantage of forming cobalt disilicide by a process that does not leave stringers of one or more oxides of titanium.]

The present invention provides a structure, comprising a layer of cobalt disilicide, wherein the layer of cobalt disilicide is substantially free of cobalt monosilicide, and wherein there is substantially no stringer of an oxide of titanium on the layer of cobalt disilicide.

The present invention provides a structure, comprising:

a layer of cobalt disilicide, wherein the layer of cobalt disilicide is substantially free of cobalt monosilicide;

a patch of an oxide of titanium, wherein the patch is on the layer of cobalt disilicide; and

a reagent in contact with the patch at a temperature, wherein the reagent is adapted to remain in contact with the patch for a period of time, wherein the reagent removes the patch within the period of time, wherein the reagent does not chemically react with the layer of cobalt disilicide, and wherein the reagent comprises water, ammonium hydroxide, and hydrogen peroxide.

The present invention provides a structure having a substrate, wherein the substrate includes:

an insulated-gate field effect transistor (FET), wherein the FET includes a source, a drain, and a gate;

a first layer of cobalt disilicide on the source, said first layer having substantially no cobalt monosilicide, and said first layer having substantially no stringer of an oxide of titanium thereon;

a second layer of cobalt disilicide on the drain, said second layer having substantially no cobalt monosilicide, and said second layer having substantially no stringer of an oxide of titanium thereon; and

a third layer of cobalt disilicide on the gate, said third layer having substantially no cobalt monosilicide, and

said third layer having substantially no stringer of an oxide of titanium thereon.

The present invention provides a structure having a substrate, wherein the substrate includes:

an insulated-gate field effect transistor (FET), wherein the FET includes a source, a drain, and a gate;

a first layer of cobalt disilicide on the source, said first layer having substantially no cobalt monosilicide;

a second layer of cobalt disilicide on the drain, said second layer having substantially no cobalt monosilicide;

a third layer of cobalt disilicide on the gate, said third layer having substantially no cobalt monosilicide;

a patch of an oxide of titanium on a region of cobalt disilicide, said region selected from the group consisting of the first layer of cobalt disilicide, the second layer of cobalt disilicide, the third layer of cobalt disilicide, and combinations thereof;

a reagent in contact with the patch at a temperature, wherein the reagent is adapted to remain in contact with the patch for a period of time, wherein the reagent removes the patch within the period of time, wherein the reagent does not chemically react with the first layer of cobalt disilicide, wherein the reagent does not chemically react

with the second layer of cobalt disilicide, wherein the reagent does not chemically react with the third layer of cobalt disilicide, and wherein the reagent comprises water, ammonium hydroxide, and hydrogen peroxide.

Use of a FET in the preceding structures is merely illustrative, and any semiconductor structure may be used instead of a FET in the preceding structures.

The structures of the present invention have the advantage of not including, or facilitating removal of, stringers of one or more oxides of titanium.

The Abstract is amended as follows:

A [method for removing a formation of] structure relating to removal of an oxide of titanium [that is] generated as a byproduct of a process that forms cobalt disilicide within an insulated-gate field effect transistor (FET). The structure may comprise a layer of cobalt disilicide that is substantially free of cobalt monosilicide, with substantially no stringer of an oxide of titanium on the layer of cobalt disilicide. The structure may alternatively comprise a layer of cobalt disilicide, a patch of an oxide of titanium, and a reagent in contact with the patch at a temperature and for a period of time. The

layer is substantially free of cobalt monosilicide. The patch is on the layer of cobalt disilicide. The reagent is adapted to remove the patch within the period of time. The reagent does not chemically react with the layer of cobalt disilicide, and the reagent comprises water, ammonium hydroxide, and hydrogen peroxide. [The method applies a chemical reagent to the FET at a predetermined temperature, and for a predetermined period of time, necessary for removing the formation, wherein the reagent does not chemically react with the cobalt disilicide. A reagent that accomplishes this task comprises water (H_2O), ammonium hydroxide (NH_4OH), and hydrogen peroxide (H_2O_2), wherein the NH_4OH and the H_2O_2 each comprise approximately 4% of the total reagent volume. An effective temperature is 65 ^0C combined with a 3 minute period of application.]